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MONITORING OF DILATATION PROPERTIES OF CASTINGS BY SOLIDIFICATION FOUNDRY ALLOYS

SLEDOVÁNÍ DILATAČNÍCH VLASTNOSTÍ SLÉVÁRENSKÝCH MATERIÁLŮ

P. PĚNIČKA[1], J. MACHUTA[2]

ABSTRACT: The article deals with measurements of linear changes of castings from foliated graphite cast iron and Al-alloys during their solidification. For this purpose the measuring apparatus, which applies a dilatometer of Polish provenience, was built up. Dilatation curves of graphite cast iron and Al-alloys were acquired during the casting process. In the case of Al-alloys the influence of chemical composition and metallurgical treatment (use of refining salts) on linear changes during solidification and on the dimension of shrinkage originating was observed.

KEY WORDS: solidification, dimensional changes, Al and Zn alloys

1 INTRODUCTION

At the casting production it is necessary to secure not only their quality (accuracy, geometry, surface roughness, structure homogeneity, minimal internal stress, etc.), but also removing the linear and volume changes of their dimensions. In the case of casting alloys it is necessary to observe the linear and volume changes especially in the course of solidification in the case of Al-Si-alloys the eutectic silicon crystallization is important. The course of volume changes of castings defines the casting material ability to equalize the loss of volume during solidification in an effective way. The volume changes at the process of graphite cast iron solidification have been observing for a long period GEDEONOVÁ [2] and recently our Department of Engineering Technology at the Technical University of Liberec has been concerned with this issue. At present we are carrying out experiments with Zn alloys and Al alloys.

In this contribution we would like to get acquainted professional technical public with our research results.

2 SHRINKAGE OF CASTING ALLOYS

The molten metal have considerably more volume than the solidified casting. There are three quite different contractions to be dealt with when cooling from the liquid state to room temperatures. As the temperature reduces, the first contraction to be experienced is that in the liquid state. This is the normal thermal contraction and volume of the liquid metal reduces almost exactly linearly with falling temperature. In the casting situation the shrinkage of the liquid metal is usually not troublesome, the extra liquid metal required to compensate for this small reduction in volume is provided without difficulty. The contraction is quite another matter, however. This contraction

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[1] Ing. Pavel Pěnička, student Ph.D. – Department of engineering technology, TU of Liberec
[2] Ing. Jiří Machuta, student Ph.D. – Department of engineering technology, TU of Liberec

occurs at the freezing point, because in general of the greater density of the solid compared to of the liquid. Contraction associated with freezing for a number of metals are given in Table 1. The contraction causes a number of problems. These include requirement for feeding, which is defined here as any process that will allow for the compensation of solidification contraction. Solid contraction is very important process for production of the pattern. The contraction of the casting from its freezing temperature to room temperature are dependent on the castings methods. There is no considerable refilling of the molten metal loss during solidification in the case of Al-Si-alloys. The volume growth by the influence of silicon solidification is not able to equalize the volume loss, arisen at Al crystallization. Therefore, it is necessary to riser castings made from Al-alloys, especially at the gravitational casting process. Shrink occurrence in this case is connected with the way of solidification. The way of casting solidification, reflections of its internal pressure ratios and external volume change are possible to observe by dilatation measuring.

Tab. 1 - Solidification shrinkage volume and linear contraction for some metals

Metal	Volume changes [%]	Coefficient dilatation [K^{-1}]	Approximate linear contraction to 20 °C [%]
Aluminium	7,14	$23{,}6.10^{-6}$	0,8 to1,4 (Al-alloys)*
Zinc	4,08	$27{,}6.10^{-6}$	0,8 to1,6 (Zn-alloys)*
Magnezium	4,10	$27{,}5.10^{-6}$	0,8 to1,6 (Mg-alloys)*
Tin	-3,32	$23{,}0.10^{-6}$	0,5*
Silicium	-2,90	$7{,}8.10^{-6}$	-
Iron	3,16	$11{,}7.10^{-6}$	2,2*

Commentary: *) linear contraction in the sand mould

3 EXPERIMENTAL OBSERVING OF CASTING ALLOYS CONTRACTION

For the measurements of casting alloys dilatations has built up at our department (Department of Engineering Technology, Technical university of Liberec, Czech Republic) a complete measuring apparatus Fig. 1. The casting has shape of " I " profile Fig. 2. This experimental following predisposition to crack was made on measurement apparatus according to Bocvar and Svidersky. Apparatus was constructed as the last century in our work place. Measurement apparatus is tied in a dilatometer and a computer and make it possible adjust to definite power which this power can give rise stoppage shrinking of solidify casting. It may cause his damage. This apparatus make it possible register of time dependence of linear shrinkage of the experimental casting by his cooling too. Cavity of casting is open and it's from three parts – metal plate, sand part 108 mm long with middle part of casting and moving part. Experimental casting has middle part with diameter 25 x 11 mm. Sand part make it possible production of thermal area in casting. Castings solidify last in this place. Moving part is tied with compressive for making tension force by tension bar.

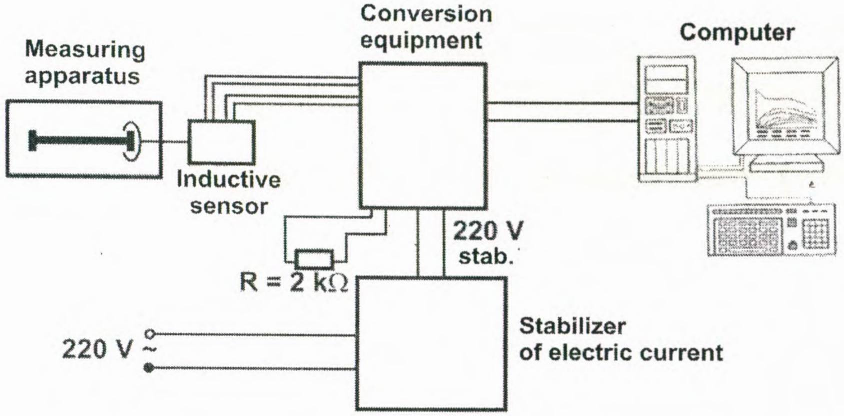
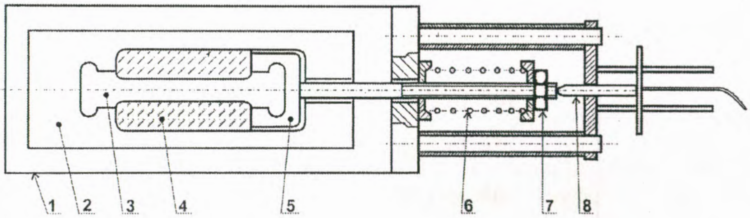


Fig. 1 - Schema of the measuring apparatus of the contraction



1 - bolster; 2 - metal plate; 3 – casting cavity; 4 - sand mixture cavity; 5 - moving shaped metal plate; 6 - compressive; 7 - nut;
8 – measuring detection of dilatation

Fig. 2 - Scheme measurement bolster with cavity of casting to Bocvar and Svidersky

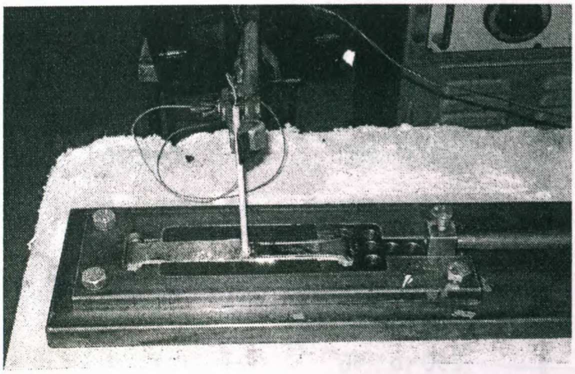


Fig. 3 - Frame measure with casting to Bocvar and Svidersky test

The measurements of dilatations of Zn alloy and Al-alloy were carried out on this measuring apparatus. Measurements were carried out in moulds the homogeneous forming bentonite mixture and in a steel mould. Measurements were carried out in moulds the homogeneous forming bentonite mixture and in a steel mould. For casting melts were used Zn alloy(ZnAl4Cu3) and Al alloy (AlSi7). Temperature castings has been applied 450°C and 550 °C. The experiments themselves were monitored by means of measuring apparatus Fig. 1. For temperature measuring in the heat axis of the casting, the thermocouple NiCr-Ni with conductor diameter 0.2 mm was used. It was protected by a corundum two-capillary LUXAL. It enables to find out time dependencies of temperatures in the heat axis of the casting and has been measured dependence solid contraction of casting on the time. There are the linear contraction of zinc and Zn and Al alloys casting are in table 2 and table 3. Figure 4, 5 show the dependence of linear contraction and temperatures on the times.

Tab. 2 - Solidification shrinkage volume and linear contraction for alloy AlSi7

Temperature [°C]	α [K^{-1}]
650 to 600	7,54.10-6
600 to 550	$1,31.10^{-5}$
550 to 500	$9,30.10^{-6}$
500 to 450	$2,26.10^{-6}$
450 to 400	$1,35.10^{-5}$
400 to 350	$3,03.10^{-5}$
350 to 300	$5,27.10^{-5}$
300 to 250	$7,63.10^{-5}$
250 to 200	$10,13.10^{-5}$
200 to 150	$12,54.10^{-5}$
150 to 100	$15,02.10^{-5}$
100 to 50	$17,84.10^{-5}$

Comment: *) temperature casting 720 °C

Tab. 3 - Solidification shrinkage volume and linear contraction for alloy ZnAl4Cu3

Temperature [°C]	α [K^{-1}]
500 to 450	$1,45.10^{-6}$
450 to 400	$2,98.10^{-6}$
400 to 350	$6,03.10^{-7}$
350 to 300	$2,22.10^{-5}$
300 to 250	$4,33.10^{-5}$
250 to 200	$6,71.10^{-5}$
200 to 150	$9,33.10^{-5}$
150 to 100	$12,06.10^{-5}$
100 to 50	$15,04.10^{-5}$

Comment: *) temperature casting 550 °C

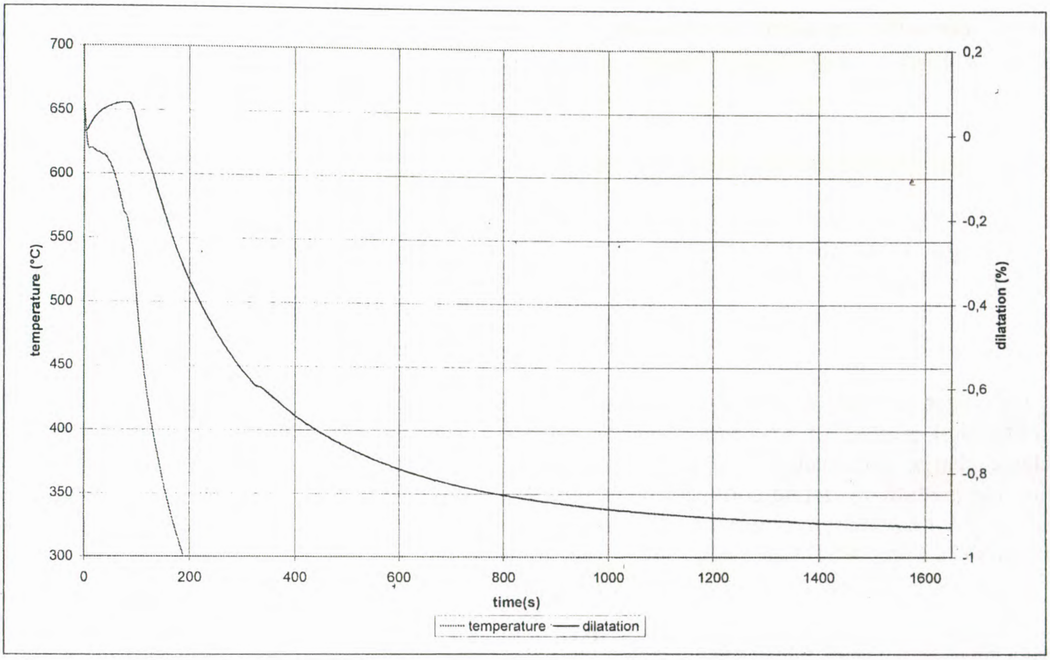


Fig. 4 - Time dependencies temperature and dilatation of the castings alloy AlSi7 into mould (Bocvar – Svidersky) for temperature casting 720°C and for lenght 157 mm.

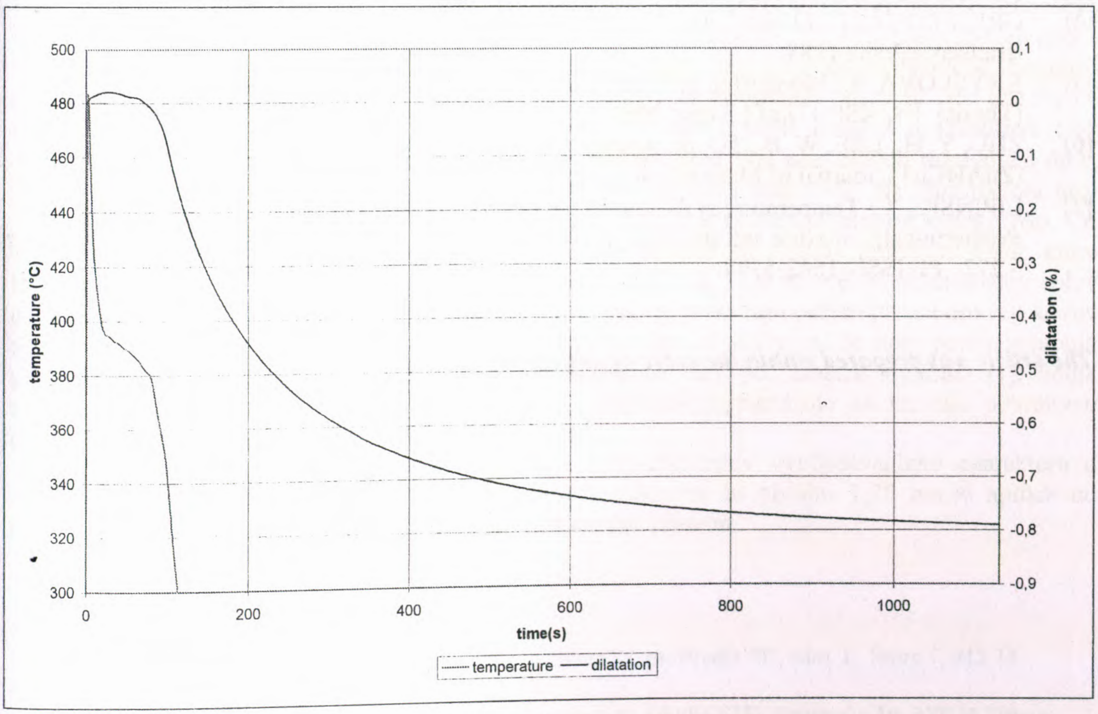


Fig. 5 - Time dependencies temperature and dilatation of the castings alloy ZnAl4Cu3 into mould(Bocvar – Svidersky) for temperature 550°C and for lenght 157 mm.

From the curve dependence expansion on the temperature bas been calculated α coefficient of thermal contraction (expansion) for Al and Zn alloys, Tab. 3. It was used equation:

$$\alpha = \frac{\Delta l}{l_O(T_2 - T_1)} \quad [K^{-1}] \qquad /1/$$

Δl - is contraction of the casting [mm],
l_0 - is original length of casting [mm],
(T_2-T_1) - is difference of temperature [°C].

3 CONCLUSION

The paper presents knowledge of exact possibility of assessment of the dilatation course at the solidification process of Zn and Al alloys. Decisive parameters of tests are the influence of the metallic charge composition, the degree of melt overheating, chemical composition of Zn and Al alloys the method of casting cooling and the type of the mould. Values of the contraction curves has been used for calculation thermal coefficient of contraction. The thermal coefficients of contraction (500 to 50 °C) are: AlSi7=15,59.10 $^{-5}$ [K^{-1}], ZnAl4Cu3=12,31.10 $^{-5}$ [K^{-1}].

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